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EXPERIMENTS

IN

PNEUMONECTOMY AND PNEUMONOTOMY.

BY

DE FOREST WILLARD, M.D., PH.D.,
SURGEON TO THE PRESBYTERIAN HOSPITAL; CLINICAL PROFESSOR OF ORTHOPÆDIC SURGERY IN THE UNIVERSITY OF PENNSYLVANIA, PHILADELPHIA.

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Dr. De Forest Willard

EXPERIMENTS IN PNEUMONECTOMY AND PNEUMONOTOMY.

By De FOREST WILLARD, M.D., Ph.D.,
SURGEON TO THE PRESBYTERIAN HOSPITAL; CLINICAL PROFESSOR OF ORTHOPÆDIC SURGERY IN THE UNIVERSITY OF PENNSYLVANIA, PHILADELPHIA.

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The results that have followed the application of correct surgical principles in the evacuation of purulent accumulations in the pleural cavity, either by drainage or by the resection of one or more ribs, certainly invite us to still further invasion of the thoracic cavity. With the advances in surgery made possible by increased knowledge, by improved technique, and by the application of safe antiseptic measures, further success may be expected.

Operations for abscess of the lung substance, for gangrene, tumors, cysts, etc., are increasing, and many successes are recorded. In this class of cases the resulting inflammation, as a rule, has bound the lung to the thoracic wall before the surgeon has attempted to enter the diseased area; hence, operative infection of the pleural cavity is not probable, although the disease may have invaded this space before any incision is attempted.

Tubercular abscesses with slight resulting pleurisy do not, as a rule, unite the lung to the costal pleura, and any invasion through the two separated pleural layers would necessarily lead to contamination of the pleural sac.

It has long been my hope and expectation that tubercular abscess in the lung would be reached, drained, and locally treated. If adhesion has taken place, such invasion would be feasible; but in many cases, especially at the apex, adhesion of the two surfaces does not occur. In these cases, therefore, primary operation

becomes necessary in order to secure adhesion and a direct communication with the outer world, which route should be walled in so thoroughly that the tubercular material cannot infiltrate either the pleural cavity or the general system.

The following experiments were performed to test the possibility of the production primarily of such adhesion, and also to determine the tolerance of the lung to secondary incision into its tissue.

One of the plans adopted was to drag the lung into the chest incision and secure it firmly *in situ*, causing it thus to form a firm plug at the opening, which plug should become firmly adherent around the circumference. By this method free escape of the diseased product could be primarily secured while the pleural cavity would be shut off.

Another method consisted in lightly suturing the opposing pleural surfaces, in order to produce an adhesive inflammation.

These experiments are too few in number to give a positive result, but, taken in connection with my experiments in bronchotomy through the chest-wall (*Amer. Journ. Med. Sci.*, December, 1891; *Trans. Amer. Surg. Assoc.*, 1891), they show the existence in the dog of a remarkable tolerance to lung interference.

Experiment I.[1] *Primary suturing of lung; secondary pneumonotomy; recovery.*—A small-sized Scotch terrier, male, was etherized, shaved, and scrubbed with sublimate solution. An incision was made on the left side between the fifth and sixth ribs. There was no hemorrhage when the pectorals and intercostals were divided. There was partial collapse when the pleural cavity was opened; ether was then suspended. The lower lobe of the lung was caught with blunt hæmostatic forceps, drawn to the opening, and sutured to the circumference with chromicized catgut. There was no bleeding from the muscular tissues, and but little from the needle-holes in the lung. The wound was sutured with silk, cleansed with sublimate solution, and dressed with iodoform and collodion. The dog was in bad condition and breathing rapidly, but he walked about in ten minutes.

On the following day the dog was perfectly well, and apparently had suffered nothing from the wound. On the ninth day the stitches had given way, and the wound was accordingly opened. It presented a granulating surface covered with healthy pus. The pectoral muscle, which had united, was torn through with the finger. The adhesions around the opening were

[1] For most helpful assistance in these experiments I am indebted to Drs. Joseph Sailer and W. M. Hinkle, and to Mr. William R. Nicholson, Jr.

found firm and strong. The lung was adherent to the thoracic wall, but during the manipulations these adhesions were partially torn.

An incision was made into the lung substance for about one-third of an inch in depth. Hemorrhage was very profuse for a few minutes, but steadily lessened. The incision was packed with a roll of sublimate cotton, and from that time there was no further bleeding. The edges of the wound were drawn loosely together and a roll of cotton placed at the exit.

The dog had no fever, and continued well. On the third day it was found that he had removed the plug, but no hemorrhage followed, and he remained in good condition. A pair of forceps, which were carried into the wound to search for the plug, drew out a large clot. It was not offensive, but its removal was followed by a free hemorrhage for a few minutes.

The dog was killed at the end of the fourth week. The wound had entirely healed, and he had never been sick or lost his appetite since the second day. The lung was found closely adherent everywhere about the wound, with firm cicatrices of the lung substance where it had been incised. There was no sign of pus anywhere. The pleura was smooth and perfectly healthy, and there was no effusion. There was only the ordinary amount of normal serum, and no roughness or lymph. The membrane was smooth and glistening, and there was no inflammatory trouble in the lung tissue around the site of the operation.

EXPERIMENT II. *Suturing of lung; adhesion of pleural surfaces; secondary pneumonotomy, followed by septic infection from accidental rupture of adhesions.*—A black and white spaniel, of moderate size, was etherized, shaved, and cleansed. Incision was made between the seventh and eighth ribs on the left side, and the intercostal muscles laid bare. Without opening the thorax, a chromicized catgut ligature was carried through the muscles, then through the lung, by a handled, sharply-curved needle. Two sutures were inserted. The wound was closed antiseptically with silk sutures, and dressed with iodoform and collodion. The dog rallied in about five minutes. The animal was in good condition, and did fairly well until the tenth day, when the wound was re-opened. The pleura was found adherent with considerable firmness to the lung at the line of suture between the seventh and eighth ribs.

An incision was made into the substance of the lung. Bleeding was slight, and was arrested by simply packing the wound. Some of the adhesions were accidentally broken down, which permitted the entrance of air into the cavity, and probably of some drops of pus from the granulating surface. The wound was freshened, sutured, and closed. Purulent infection, however, from the opening into the pleural cavity spread and induced septic pleurisy, from which the dog died on the second day following.

The serous cavity contained a large amount of fetid pus, and the lung had collapsed. The adhesions around the site of operation had, of course, entirely given away under the suppurative process. The wound had not closed.

An error was probably made in rupturing the adhesions and then in attempting to induce reunion of the wound by paring away all the granulation tissue, freshening the surface, and reuniting the skin with sutures, as these methods were productive of inflammation.

Dogs are so restless under any dressing that it is impossible to keep them aseptic, except by fixing the antiseptic dressings with a bandage of gypsum.

Experiment III. *Attempt to produce adhesive inflammation of the pleura by Paquelin cautery.*—A white, stout, moderate-sized, black mongrel was etherized, shaved, and disinfected. Incision was made on the left side near the fifth interspace down to the intercostal muscles. A Paquelin cautery was employed, but, as usual, the knife failed to work properly, and cooled so rapidly that it was useless. I had with me at the time only one other cautery-point, a large, round-headed one, and with this the perforation of the intercostal muscles was slow. The lung was undoubtedly pushed before the instrument away from the walls, and the lung substance was not entered. Had the sharp instrument worked properly such perforation might have been possible, but with a dull, round ball the operation was necessarily a failure. As the dog seemed to be suffering, he was killed on the following day. A few drops of pus were found in the pleural cavity. The operation was done to determine whether a route could be rapidly tunnelled into the lung, and at the same time unite the pleural surfaces and permit drainage or subsequent cutting operation.

Experiment IV. *Thoracotomy; pneumonectomy; suturing of lung in the wound; union.*—A small brown and white terrier was etherized, shaved, and disinfected. An attempt was made to perform a thoracotomy and then a bronchotomy. An incision was made through the muscles to the pleura, about three inches of which were exposed in the left seventh interspace. The pleura was incised with resultant pneumothorax. The bronchus of the left side was found, but it was so thoroughly surrounded by the pulmonary vessels that it could not be safely incised. The operation was, therefore, abandoned and pneumonectomy substituted. The lower lobe was drawn out of the opening and a probe passed through it. A ligature was then thrown round the lung and tightened, and the projecting portion of the lung cut off. The ragged edges which interposed were sutured to the interspace and the wound closed as before. The dog recovered in half an hour, and on the following day ate and slept well.

Thirty-five days later the dog was killed, the soft parts having entirely healed. On opening the cicatrix the lung tissue was found in the intercostal space firmly fixed, but healthy. There was no sign of pus at any point. The lung was firmly adherent to the thoracic wall, as shown in the specimen. The pleura was smooth, and there was the usual amount of normal serum in the cavity. The dog did not seem to suffer from the operation.

Experiment V. *Suturing of lung; firm adhesions produced without pleurisy.*—A white and black male dog, weighing eight pounds, was etherized,

cleansed, and prepared as before. An incision was made at the fourth rib, three inches long, extending through the pectoral muscles, but not through the intercostals. With a handled, sharply-curved needle a fine chromicized stitch was carried through the intercostal muscles between the third and fourth ribs and into the lung, emerging one and one-quarter inches nearer the sternum. A similar stitch parallel to the line of the first was carried for the same distance in the interspace between the fourth and fifth ribs. From the point of emergence of these stitches cross stitches were carried in a similar manner, the needle being pushed into the third interspace through the lung beneath the rib, emerging at the fourth interspace. These were lightly drawn, so as not to cut through the lung, but simply to approximate the visceral and parietal pleuræ without producing any sloughing of the lung or of the muscles. A parallelogram of lung was thus brought closely against the walls of the chest, and the opposing pleural surfaces were constantly in apposition. The muscles and skin were separately stitched and iodized collodion applied over all. The dog seemed to suffer no inconvenience and rallied quickly. He appeared perfectly well until he was killed on the tenth day. At the autopsy the pleural surfaces were firmly adherent throughout the whole extent. There was no roughening of the pleura, no effusion of serum, or any evidence whatever of lung injury.

Experiment VI. *Suturing of lung without opening into the pleura; excellent adhesions.*—In a white male pup, weighing six pounds, incision was made on the left side over the fourth rib. The pectoral muscles were divided, but the intercostals were not cut. A handled, sharply-curved needle, threaded with chromicized catgut, was passed through the fourth interspace into the lung and out through the intercostal muscle one and one-half inches higher. This was tied just sufficiently tight to keep the two pleural surfaces in apposition, but not to produce sloughing. A parallel suture was similarly placed in the third interspace, and cross sutures were carried beneath the rib from one interspace to the other at the ends of each. The lung was thus brought in apposition with the parietal pleura by sutures on the four sides of a parallelogram. The pectoral muscles were then sutured continuously, and the wound closed with interrupted sutures. The dog rallied and seemed in good condition half an hour later. When killed, twenty days later, the pleural surfaces were found to have united with great firmness, and, other than the adhesions, there was no evidence whatever of pleurisy. The lung substance presented no evidence of inflammation.

Dr. Sailer and Messrs. Patek and Bolgiano[1] reported a series of experiments made upon dogs, in order to determine the possibility of operative interference upon the lung.

In their first attempt they cut off a piece of lung and returned

[1] University Medical Magazine, May, 1891, p. 473.

the stump with the ligature into the thoracic cavity. Of four animals experimented upon, one died upon the table, two died the day after the operation, and one died on the fifth day. The autopsies showed gangrene of the stumps and empyema.

A different method of operation was then employed. The lung was drawn out of the thorax, freely cut away, and fastened by antiseptic catgut sutures to the intercostal muscles. The pleura and lung were washed, and the lung sutured in position as a plug at the opening. Sutures were inserted throughout the entire circumference of the wound and the skin incision was then closed over catgut drains.

In three dogs operated upon little hemorrhage occurred and there was but little shock. They reacted well and there was but a slight rise in temperature. The appetite continued good. One dog was killed on the tenth day. There was perfect adhesion to the thoracic wall, without pleurisy. The second dog lived for three weeks. A small cicatrix upon the upper lobe of the lung had become detached from the thoracic wall. In the third dog the whole upper lobe of the left lung was removed. Recovery was prompt and he was permitted to live.

Zakharevitch[1] experimented upon thirteen rabbits and eleven dogs, and made nine operations upon the human cadaver. He resected sub-periosteally from the first to the fourth ribs, and tied the lung off at the root with silk; then cut it away, applied iodoform, stitched the wound, and covered with the usual antiseptic dressings. Of eleven operations upon seven dogs, three were fatal. One dog lived four years after the second operation, then died of accident. On examination, the remaining part of the lung was always found enlarged and developed. If one lung is sound, the chances of a dog even after total pneumonectomy of one side are good; if the remaining lung is weak, then the dog usually perishes. In thirteen operations on nine rabbits, two were fatal.

As the roots of the upper and middle lobes of the lung are opposite to the third interspace, and that of the lower lobe to the fourth interspace, Zakharevitch recommends excision of the second rib to

[1] Annual of the Universal Medical Sciences—Sajous, Philada., 1890, vol. iii. B. 26.

reach the upper two lobes, and of the third rib to reach the lower lobe. For maintaining drainage it is sometimes desirable to open the eighth intercostal space at the posterior axillary line. Free incision and free resection give the best results.

My experiments above detailed, though few in number, prove at least that adhesive inflammation can be induced between the two pleural surfaces by subcutaneous suturing, and that a route of entrance can thus be readily secured; also, that the lung may be incised or a portion of it removed without serious injury to the animal.

The value of these experiments in a surgical view is as yet largely undetermined.

In regard to tubercular abscesses, the resulting inflammation necessarily accompanying the tubercular process will sometimes agglutinate the lung to the thorax and an entrance will thus be easy. When that does not exist, however, a primary entrance can be secured by drawing the lung into the opening after the resection of a couple of the ribs and then suturing it circumferentially at the opening to make a plug; or a primary opening for the purpose of securing adhesion might be performed and the pneumonectomy be made secondarily.

Ledyard[1] localized a tubercular cavity in the lung with probable adhesion and thickening of the pleura. He incised in the fifth interspace at the anterior axillary line; excised the sixth rib, cut into the lung, washed with a boric acid solution, and found a large cavity surrounded with calcareous masses. No serious cough was produced. A drainage-tube was inserted, but the patient died on the sixth day. At the necropsy, the posterior part of the lobe was found adherent everywhere; within it was an oval cavity the size of a goose-egg; the external wall consisted of lung tissue and thickened pleura.

Allis, of Philadelphia, recently resected three ribs opposite the posterior axillary line, opened the pleural cavity, and stitched the lung into the opening. He then incised the lung without hemorrhage, and although reaching a tubercular cavity, found no pus.

[1] Lancet, May 13, 1890.

The child died in forty-five hours. There was no bleeding and the lung substance around the cavities was solidified.

Porter[1] made an opening through the chest wall in a case of fetid abscess of the lung following pneumonia. The fourth, fifth, and sixth ribs were resected for two inches and a half. He had first drained the pleural cavity, but did not reach the lung. In the second attempt, in which resection was performed, the diaphragm was cut and sutured. There was a large amount of pus in the lung. Drainage was free. The fetor of the breath disappeared in a few days, and the man was well in four months, with no cough and no expectoration. Porter records two cases,[2] and says that the condition of abscess of the lung admits of positive diagnosis. It arises from occlusion of an artery from inflammatory conditions which lead to gangrene. Excision of a rib gives the best results, as it makes a free opening for drainage.

In gangrene of the lung, while the results are not very hopeful, yet the benefit to be derived from the operation is sufficient to warrant surgical interference. The operation in such a case gives an opportunity for the escape of material which must otherwise certainly kill the patient. Antiseptic washings ought to be instituted, but they should be exceedingly weak, and probably free washings with distilled water would be equally of service. Removal of the débris and mopping the grangrenous region with peroxide of hydrogen is useful. The dead tissue should be pulled, rather than cut, so as to prevent hemorrhage. Air and hot water act as powerful hæmostatics upon the lungs of dogs, and the same agents have a similar effect upon the human structures. Strong washings should not be continued, since, as is often the effect in empyema, they are not productive of good. The mechanical removal of pus by a stream of hot water is, however, feasible and safe. Thorough attention to details of asepsis and antisepsis is an essential element in all intra-thoracic surgery.

My own experience is in accord with Teale's[3] conclusions, that

[1] Philadelphia Hospital Reports, vol. i. p. 165.

[2] Journal American Medical Association, March 7, 1891; University Medical Magazine, March, 1891, p. 493.

[3] Boston Med. Journ., October 13, 1888.

it is not merely the presence of air in the pleural cavity which gives danger, but that in the healthy lung the great inrush of air that takes place when the chest is opened, seriously interferes with thoracic movements, and is a much more serious matter than when the lungs have been slowly crippled by disease. I have freely opened the chest in a large number of cases of empyema, both with and without excision of the ribs, and have seen no serious result from the pneumothorax produced. In gangrene of the lung, the organ being already crippled, the incision of the thoracic walls may be free. In Allis's case, referred to above, the diseased and solidified lung did not collapse when the pleura was opened. In deep abscesses the Paquelin cautery to provoke adhesion of pleural surfaces, might be useful; but in gangrene the plan adopted by Hofmokl, that of penetration with the Paquelin cautery,[1] does not seem wise, as free escape is best.

Osler[2] reports a case of bronchiectasis, in which the patient had felt a sensation of fulness in the left side for many years, although there was no especial difference in appearance in the two sides of the chest. The sputa were purulent and moist, with fetid pus; no elastic tissue or tubercle bacillus could be discovered. Portions of the fourth and sixth ribs were excised and the cavity opened and stitched. The patient died on the third day.

Laacke records an operation for bronchiectasis, in which the patient lived for eighteen months and then died of brain trouble.

Several cases are reported of incision made for pneumonia with recovery of the patient. The ribs excised were in the axillary line; antiseptic dressings were used and the patients recovered.

B., aged twenty. An incision was made in the fifth interspace through the left anterior axillary line. The sixth rib was excised; the lung cavity was incised and washed with boric acid. The cavity was found to be surrounded with a caseous mass. Drainage-tubes were inserted. The patient died on the fourth day. *Post-mortem:* Left lung adherent everywhere.

Koch[3] made an incision into the lung substance for pleuro-pneumonia, having resected the fifth and sixth ribs. The thermo-cautery was used to reach the abscess. Irrigation and drainage were prac-

[1] Annual of the Universal Medical Sciences—Sajous, 1889, N. 9.

[2] Bronchiectasis, Johns Hopkins Bulletin, 1889 and 1890, p. 109.

Annual of the Universal Medical Sciences—Sajous, 1890, vol. iii. B. 26.

tised. The patient was well in eighty-one days. One and a half years later, the patient was reported as being in good condition.

Vinesse[1] advises against too extensive a resection, and Ollier states that in young and hearty subjects excess of periosteum should not be left, as it is likely to produce bone.

Bull[2] reports two cases of gangrene operated upon; and Thue, in the same journal,[3] gives other cases successfully drained, although one patient subsequently died of pericarditis.

Jones has operated on three cases of abscess of the lung, and considers alcoholism as the chief factor of the disease. Lassier, of Kiel, reports six cases; Ruenberg eight—all operated on. With Jones's three, there have been thirty cases, exclusive of Graves's six successful ones.

Conclusions.—1. The writer's experiments in thoracotomy and in bronchotomy[4] show that the entrance of air into the pleural sac is a far more serious matter when the lung tissue is normal than when it is diseased or already crippled, both as regards the collapse of the lung and the danger to the patient.

2. Incision into the substance of the lung and removal of a portion is well borne in dogs. Hemorrhage, though free, is not fatal, and can be arrested by packing.

3. Adhesion of the parietal and visceral layers can readily be obtained by sutures, and the resulting pleurisy is slight.

4. Surgically these experiments demonstrate that adhesive inflammation can be secured, thus permiting safe incision into tubercular or other diseased lung tissue without infection of the pleural sac.

5. A lung can be drawn into the wound made by excision of the ribs, and so sutured to the edges of the opening that the pleural cavity can be cut off.

6. Pulmonectomy performed for gangrene or for abscess of the lung offers better results than are possible in cases not treated surgically.

[1] Congress Française de Chirurgie, 1889, p. 219.

[2] Norsk Mag. f. Laegevidensk. Christiania, 1891, 4 R. vi. p. 289.

[3] Norsk Mag. f. Laegevidensk, p. 271.

[4] American Journal of the Medical Sciences, December, 1891; Transactions of the American Surgical Association, 1891.